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## Analysis of Flutter in Tape Transport Systems

A study was made to determine the effect of flutter on digital data recorded by magnetic tape recorders used with instrumentation systems and to propose a method for smoothing the consequent bit rate variations in the data. Flutter is treated from the standpoint of tape velocity variations during the record and playback operations. The major flutter effect for both FM and direct recording techniques is shown to be a perturbation of the signal time base.

General expressions for flutter perturbed signals are derived, and applied to a sinusoid perturbed by sinusoidal flutter. Such flutter is shown to introduce sidebands about the frequency of the sinusoid spaced at intervals of the flutter frequency. Random or Gaussian flutter with a constant spectral density (which closely approximates actual flutter) is shown to "smear" the power of a sinusoid about the recorded frequency. The effect of Gaussian flutter on a digital signal is a Gaussian variation of bit rate and bit-to-bit spacing.

A buffer system is proposed for smoothing the Gaussian bit rate variations in digital data. The proposed system is shown to attenuate bit rate variations at the rate of 6 db/octave above a frequency twice that of the natural frequency of the buffer control loop. The buffer is a flip-flop register in which the incoming bits are stored serially until read out by gating circuitry. The rate at which the bits are read

from the buffer is equal to the frequency of a voltage-controlled oscillator (VCO), which consists of a multi-vibrator with a center frequency equal to the recorder mean bit rate. The voltage for controlling the VCO frequency is derived by sensing the number of bits stored in the buffer above or below a set reference level of bits. The output voltage from a queue sense circuit is filtered by a low pass filter. The filtered output is used to control the VCO frequency, hence the output bit rate.

### Note:

Inquiries concerning this invention may be directed to:

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Reference: B68-10027

### Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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Marshall Space Flight Center  
(MFS-11970)

Category 01

33126 H037 A241